United States
Environmental Protection
Agency

Air and Radiation
Acid Rain Division (6204J)
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Acid Rain Program Emissions Scorecard 1996

SO_2, NO_x, Heat Input, and CO_2 Emission Trends in the Electric Utility Industry

Background

Acid Rain Program Overview

Established under Title IV of the Clean Air Act Amendments of 1990, the Acid Rain Program requires the electric utility industry to reduce emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x), the pollutants that cause acid rain. To ensure that the desired emissions reductions are achieved, the program implements an innovative market-based regulatory approach under which utilities have flexible compliance options. The program was designed to be implemented in two phases: Phase I (1995 through 1999) and Phase II (year 2000 and beyond). Phase I requires emissions reductions from the highest-emitting boilers at 110 large power plants, while Phase II includes utility boilers and combustion turbines at more than 700 additional plants. The U.S. Environmental Protection Agency (EPA) administers the Acid Rain Program.

After each calendar year, the EPA determines compliance of each facility relating to its SO_2 and NO_x emissions requirements and publishes a report to document the results. The compliance results for calendar year 1996 for Phase I affected plants are presented in the EPA's 1996 Compliance Report, Acid Rain Program (EPA 430-R-97-025), published in June 1997. The Compliance Report further describes the Acid Rain Program's market-based regulatory approach and compliance options. The EPA also prepares this annual "Scorecard" report which contains comprehensive summary data and trends information from all Title IV affected facilities.

To ensure that nationally mandated reductions in SO_2 and NO_x emissions are achieved and documented, the Acid Rain Program regulations require most affected facilities to install Continuous Emissions Monitoring (CEM) systems at their plants to measure and record data for SO_2, NO_x, and carbon dioxide (CO_2) emissions and to record other relevant information. The Acid Rain Program regulations also require facilities to conduct a series of initial and ongoing quality assurance tests on each of their CEM systems to ensure the accuracy of the measured pollutant concentration and flow. After each calendar quarter, affected facilities must assemble the recorded data into comprehensive emissions reports and submit them to the EPA.

Emissions Scorecard 1996

The Scorecard: Emissions Data Collection and Evaluation

Much of the data contained in the Acid Rain Program's Scorecard are derived from the EPA's automated Emissions Tracking System (ETS). The EPA developed ETS to collect, analyze, and archive the quarterly emissions reports and associated data submitted by the affected facilities. ETS now contains a substantial emissions database since Phase I affected facilities began reporting data in January, 1994, and Phase II facilities began reporting data in April, 1995.

The primary function of ETS is the routine processing of the emissions reports received by the EPA after the end of each calendar quarter. ETS analyzes each emissions report and generates results that are forwarded to the facility. These results indicate any potential problems detected in the hourly, quarterly, and year-to-date pollutant and heat input data values. Other data contained in the report, including quality assurance test data and monitoring plan information, are also analyzed. In some cases facilities may need to correct problems and resubmit quarterly reports to the EPA.

After the end of a calendar year, the EPA uses the year-to-date values contained in ETS for all Title IV affected units as the starting point for creating the Scorecard. As the EPA evaluates these data, facilities have a total of five opportunities to review and comment on the EPA's understanding of their data. Before the Scorecard is published the EPA also performs other data quality checks, such as comparing current values to historical values and checking the reasonableness of the reported data. Once the data are finalized, the EPA prepares annual statistics and develops trends data for the Scorecard.

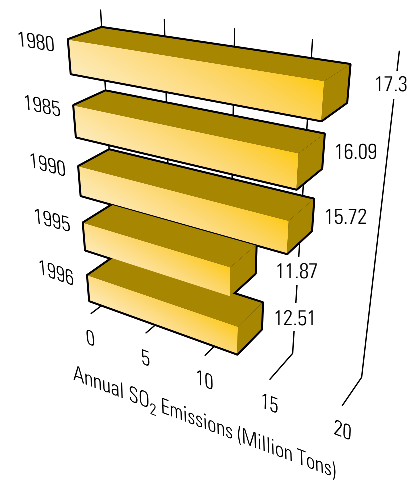

Figure 1

National SO_2 Emissions Trend for all Title IV Affected Boilers

Trends in SO_2 Emissions and Heat Input, 1980 to 1996

The long term trend in SO_2 mass emissions for all units affected under Title IV is shown in Figure 1 (the data are displayed at five-year intervals from 1980 to 1995, followed by 1996). Emissions declined gradually by about 1.6 million tons between 1980 and 1990, followed by a sharp drop of about 3.9 million tons from 1990 to 1995, which was the first year Phase I units were required to comply with the Acid Rain Program. This emissions drop was then followed by an increase of approximately 650,000 tons from 1995 to 1996, due primarily to increased utilitization.

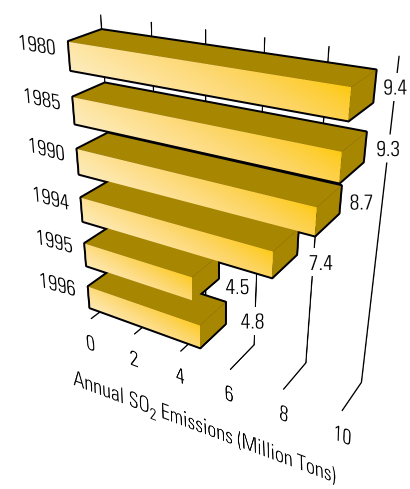

Figure 2

Phase I, Table 1 Boiler SO_2 Emissions Trend

Figure 2 shows the SO_2 emissions trend for the 263 units required to participate in Phase I of the program ("Table 1" units) over the same time period

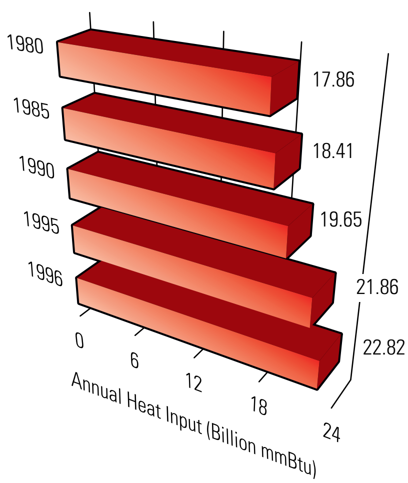

Figure 3

National Heat Input Trend for all Title IV Affected Boilers

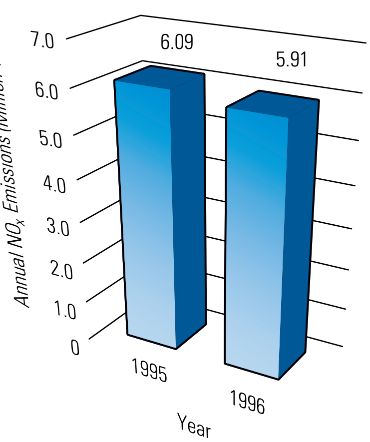

Figure 4

National NO_x Emissions in 1995 and 1996 for Title IV Affected Boilers

(including data from 1994). The emissions trend exhibited by the Table 1 units is similar to the national emissions trend shown in Figure 1, as the steep decline in national SO_2 emissions in 1995 was primarily due to emissions reductions at the Phase I units. Similarly, a significant portion of the increase in national emissions from 1995 to 1996 was due to increased emissions from Table 1 units.

There were two likely reasons for the rise in emissions in 1996. The first is that emissions rose due to increased electricity production (i.e., economic and/or seasonal demand). Figure 3 shows the trend in heat input (a measure of fuel burned and a surrogate for electricity production) for all Title IV affected units.

Based on the heat input trend illustrated in Figure 3, it appears that electricity production for all Title IV affected units has increased by an average of 1.6% per year since 1980. From 1995 to 1996 the increase in heat input for electrical production was an above-average 4.4%, accompanied by a comparable 5.4% increase in national SO_2 emissions.

The second reason for the rise in SO_2 emissions in 1996 was that facilities did not "over-comply" as much as they had during 1995. In 1995, all of the Table I units emitted 1,100,000 tons less than the total number of 1995 allowances available, enabling units to save, or "bank", these unused allowances for future use. On the other hand, 1996 emissions from these units increased so that only 780,000 allowances were banked. Apparently some facilities found it more economical to use more allowances for compliance in 1996 (perhaps because allowance prices were lower than predicted) instead of controlling their SO_2 emissions to the same degree as in 1995. This appears to be what happened since the 7.2% increase in SO_2 emissions from Table 1 units was more than the 4.0% average heat input increase from 1995 to 1996.

Trends in NO_x Emissions, 1995-1996

1996 was the first year Phase I boilers were required to limit their NO_x emission rates under the Acid Rain Program. For this reason, national NO_x mass emissions for the nation declined slightly (about 180,000 tons) from 1995 to 1996, despite the increase in heat input shown by Figure 3.

Figure 4 shows the estimated NO_x mass emissions for all Title IV affected units for 1995 and 1996.

NOTE: In 1995 certain Title IV affected units were exempted from reporting NO_x data for a portion of the year; their annual NO_x emissions were estimated from the partial-year data. For 1995 and 1996, the NO_x mass emissions were calculated by multiplying the average annual NO_x emission rate (lb/mmBtu) by the total annual heat input (mmBtu). Both of these values are reported by facilities.

Under the Acid Rain Program the NO_x emissions limit applicable to a particular coal-fired boiler is determined by the boiler firing type (design). Starting in 1996, Phase I tangentially fired and dry bottom wall-fired coal boilers were required to limit their NO_x emission rates to 0.45 and 0.50 pounds per million British thermal units (lb/mmBtu), respectively. These emission rates do not have to be achieved by each unit individually; facilities have the flexibility to enter into emissions averaging plans in which the average NO_x emission rate of participating boilers must be below the applicable emission limit. For more information on the NO_x program, is available at the Acid Rain Program web site (www.epa.gov/acidrain).

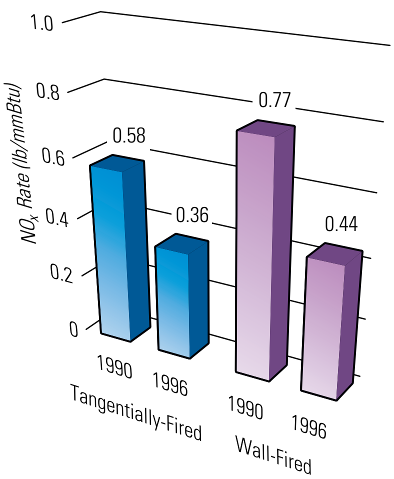

Figure 5

Phase I Average NO_x Emissions for 1990 and 1996 by Boiler Type

Figure 5 shows the 1990 and 1996 heat input-weighted average NO_x emission rates for the population of Phase I NO_x affected units, by boiler type. The average NO_x emission rates have declined substantially (over 35%) for both tangentially-fired and wall-fired boilers.

Trends in CO_2 Emissions, 1995-1996

Title IV does not require control of CO_2 emissions; it only requires that they be measured and reported. As indicated in Figure 6, emissions of CO_2 from all Title IV affected units increased by 2.8% from 1995 to 1996. This rise is comparable to the increase in heat input (electricity generated) during the same time period (Figure 3).

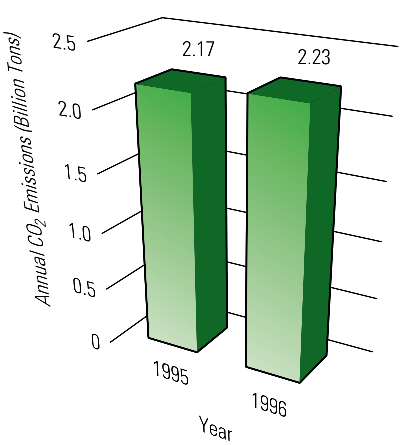

Figure 6

National CO_2 Emissions Trend for all Title IV Affected Boilers

Emissions Data Summary for 1996, by Fuel Type

Table 1 presents the 1996 national total emissions and heat input data for all Title IV affected units, apportioned by two broad primary fuel type categories (coal or non-coal). The data reflect the predominance of coal use by U. S.facilities. Of the national totals, coal units account for 85% of the heat input, 97%

of SO_2 emissions, 94% of NO_x emissions, and 90% of CO_2 emissions. Non-coal units affected by the Acid Rain Program include those that burn liquid or gaseous fossil fuel (oil, diesel, natural gas, etc.) or other solid fuel (one unit combusts wood) as their primary fuel.

Table 1

National Totals of SO_2, NO_X, CO_2, and Heat Input for Coal Fired vs. Non-Coal Fired Title IV Affected Units for 1996

Fuel	SO_2 (Tons)	NO_X (Tons)	CO_2 (Tons)	Heat Input (mmBtu)
Coal	12,105,081	5,541,584	2,010,972,798	19,510,824,887
Non-Coal	408,782	366,768	220,460,260	3,315,745,968
Total	12,513,863	5,908,352	2,231,433,058	22,826,570,855

Data Quality Assurance

A major component of the success of the Acid Rain Program is the high degree of confidence in the integrity of the allowance market. The Acid Rain Program supports this confidence by requiring affected facilities to perform and report quality assurance tests for each of their monitoring systems. These quality assurance tests ensure accurate and continuous emissions monitoring and reporting.

There are two basic types of monitors used in the Acid Rain Program: pollutant monitors and flow monitors. Quality assurance tests must be performed for both of these monitor types. Pollutant monitors measure the concentration of a pollutant present in the stack gas emitted from a unit, while flow monitors measure the volume of the emitted stack gas. The pollutant concentration data and flow data are then used to calculate emissions values. Table 2 summarizes the results for key emissions measurement quality assurance measures for 1995 and 1996.

Table 2

Emissions Measurement Quality Assurance Measures

Quality Assurance Measure	1995	1996
Percentage of RATA test results indicating < 7.5% relative accuracy for pollutant monitors	94.5%	94.5%
Median Relative Accuracy for pollutant monitors	3.22%	3.06%
Percentage of RATA test results indicating < 10% relative accuracy for flow monitors	95.0%	95.8%
Median Relative Accuracy for flow monitors	3.85%	3.54%
Mean Annual Percent Monitor Availability	95.5%	96.7%
Median Annual Percent Monitor Availability	98.4%	99%
Number of CEMS Used (Not including CO_2)	1,896	1,880

Note: The RATA test results data were omitted where reporting errors occurred.

The first key quality assurance measure is the accuracy of emissions monitors. Every six months facilities are required to perform relative accuracy test audits (RATAs) on all monitors used in the Acid Rain Program, and then calculate and report the relative accuracy (%). The relative accuracy indicates how much the monitor-reported values differ from values calculated using a standard reference method during the test. If a monitor is found to systematically under-report pollutant or flow data, the facility must correct this "bias" by applying an adjustment factor to the data reported from the monitor. This "bias adjustment factor" ensures that emissions data are not under-reported.

Pollutant monitors must demonstrate a relative accuracy of below 10% (the lower the relative accuracy, the more accurate the monitor). As an incentive to improve and maintain their monitor relative accuracy, a facility is allowed to test a pollutant monitor only once every 12 months (instead of every six months) if its relative accuracy is below 7.5%. As Table 2 indicates, over 94% of pollutant monitors qualified for the annual testing in both 1995 and 1996. The median relative accuracy (which the EPA believes to be a better measure of central tendency than the mean for this data) for these monitors improved to just over 3% in 1996.

Flow monitors must demonstrate, during Phase I, a relative accuracy of 15% and can qualify for annual testing if their relative accuracy is below 10%. As Table 2 indicates, over 95% of flow monitors qualified for the annual testing in both 1995 and 1996, and the median relative accuracy for flow monitors improved to just over 3.5% in 1996. Overall, the median relative accuracy of less than 4% for all monitors used in the Acid Rain Program strongly indicates the emissions data presented here are the most accurate of their kind.

A second key quality assurance measure is the "percent monitor availability" (PMA) data shown in Table 2. PMA indicates the percentage of unit operating hours for which measured, quality-assured data were collected by the facilities. If the data cannot be reported by a quality-assured monitor, the facilities must use EPA-developed algorithms to calculate and report substitute data values until quality-assured data are available. The calculated median PMA improved from 98.4% in 1995 to 99% in 1996. This high availability level emphasizes that CEMS are a mature and reliable technology for the measurement of atmospheric emissions. Finally, Table 2 shows the number of CEMS actually used (not just installed) to report data during 1995 and 1996.

Detailed Emissions Results for Acid Rain Program Affected Units

Detailed tabular results for the Acid Rain Program are presented in Appendices A and B. The following is a description of the contents of the Appendices.

Appendix A

Consists of two data tables: Table A1 and Table A2. The tables are described as follows:

Table A1 presents the annual SO_2 emissions and heat input data for all Title IV affected units for the following years: 1980, 1985, 1990, 1995 and 1996. The data are ordered alphabetically, first by State name and then by plant name within each State. A unique numeric code used to identify each plant, known as the "ORISPL" code, is included in a column adjacent to the plant name. The column labeled "Stack/Unit ID" identifies the stack, unit, and/or fuel pipes within the plant for which data are reported.

The SO_2 and heat input data for each plant listed in Table A1 are displayed for the stack, unit, or pipe locations, or "Stack/Unit ID", within the plant that correspond to the location of emissions monitors. In cases where different types of monitors are located at different sites within a plant or the connections between units and stacks are complicated, the data have been assimilated to the "highest" common level for ease of presentation and comparison. In the case where a stack is fed by more than one unit, the stack is referred to as a "common stack" and is prefixed by "CS" in the "Stack/Unit ID" column (the constituent units are listed in parentheses). A stack/unit arrangement where a stack is fed by more than one unit, any of which feeds another stack is called a "complex stack" and is prefixed by "XS" in the "Stack/Unit ID" column (again, the constituent units are listed in parentheses). Analogous definitions apply to common fuel pipes ("CP" prefix) and complex fuel pipes ("XP" prefix). If a single unit feeds multiple stacks, the stack values are combined and listed at the unit level. Any ID listed in the "Stack/Unit ID" column that does not contain any of the aforementioned prefixes refers to an individual unit.

Table A2 provides State-level summaries of the annual SO_2 and heat input data, for 1980, 1985, 1990, 1995, and 1996. The resulting national totals for those years are also presented at the end of the table.

Appendix B

Consists of three data tables: B1, B2, and B3. These tables are described as follows:

Table B1 presents the total annual 1996 SO_2, NO_x , CO_2, and heat input data for all Title IV affected units, along with additional descriptive information. The data are ordered alphabetically, first by state name and then by plant name within each state. A unique numeric code used to identify each plant, known as the "ORISPL" code, is included in a column adjacent to the plant name. The column labeled "Stack/Unit ID" identifies the stack, unit, and/or fuel pipes within the plant for which data are reported. The various "Stack/Unit ID" definitions used in Table B1 are discussed below.

The SO_2, NO_x, CO_2, and heat input data for each plant listed in Table B1 are displayed for the stack, unit, or pipe locations, or "Stack/Unit ID", within the plant that correspond to the location of emissions monitors. In cases where different types of monitors are located at different sites within a plant (for example, when SO_2 and NO_x are monitored at different locations) or the connections between units and stacks are complicated, the data have been assimilated to the "highest" common level for ease of presentation and comparison. In the case where a stack is fed by more than one unit, the stack is referred to as a "common stack" and is prefixed by "CS" in the "Stack/Unit ID" column (the constituent units are listed in parentheses). A stack/unit arrangement where a stack is fed by more than one unit, any of which feeds another stack, is called a "complex stack" and is prefixed by "XS" in the "Stack/Unit ID" column (again, the constituent units are listed in parentheses). Analogous definitions apply to common fuel pipes ("CP" prefix) and complex fuel pipes ("XP" prefix). If a single unit feeds multiple stacks, the stack values are combined and listed at the unit level. Any ID listed in the "Stack/Unit ID" column that does not contain any of the afore-mentioned prefixes refers to an individual unit.

NOTE: Table B1 displays both the average NO_x emission rate (lb/mmBtu) and the NO_x mass emissions (tons). Under the Acid Rain Program facilities are only required to report the average NO_x emission rate. As a result, the NO_x mass emissions values contained in the table were calculated by multiplying the annual average NO_x emission rate by the annual total heat input, and the resulting value then converted to tons.

Table B1 also contains five columns that provide descriptive information (in a coded format) about each Stack/Unit ID listed. These columns are labeled "Phase," "Status," "Fuel," "SO_2 Controls" and "NO_x Controls," and their associated codes are described below:

Phase describes the Acid Rain Program "phase" classification for each stack or unit. The phase codes are defined as follows:

P1	Phase I, Table 1 unit (263 units)
P1.5	Phase I, Non-Table 1 unit (e.g., a Phase II unit that elected to become a Phase I substitution unit or compensating unit for a Table 1 unit as a compliance option in 1996, or a unit that opted-in to the program for 1996)
P2	Phase II unit

Status describes the operating status of each stack or unit. The status codes are defined as follows:

DF	Deferred unit, did not operate in 1996 (typically has been in long-term shutdown since before 1995), but is affected under Title IV
RE	Retired unit
FU	Future unit (planned or under construction), will be affected under Title IV when operational
Blank	Operational (no permit exemptions), affected under Title IV

Fuel describes the primary fuel used by each unit. The fuel types are:

Coal	
Oil	
Gas	
Wood	
NR	Primary fuel type was not reported for the Unit/Stack ID

SO_2 Controls describes the type of SO_2 control technology (scrubber), if any, reported as installed as of the end of 1996 for the Stack/Unit ID. Facilities employ these controls in order to assist or assure compliance with SO_2 emission requirements under the Acid Rain Program or other regulatory programs. The control codes are defined as follows:

DA	Dual alkali
DL	Dry lime FGD (flue gas desulfurization)
MO	Magnesium Oxide

SO_2 Controls - continued

O	Other
SB	Sodium based
U	Uncontrolled
WL	Wet lime FGD
WLS	Wet limestone
Blank	No information reported for the Stack/Unit ID

NO_x Controls describes the type of NO_x control technology, if any, reported as installed as of the end of 1996 for the Stack/Unit ID. Facilities employ these controls in order to assist or assure compliance with NO_x emission requirements under the Acid Rain Program or other regulatory programs. The control codes are defined as follows:

LNB	Low NO_x burners without overfire air
LNBO	Low NO_x burners with overfire air
LNC1	Low NO_x coal and overfire air option 1
LNC2	Low NO_x coal and overfire air option 2
LNC3	Low NO_x coal and overfire air option 3
CM	Combustion modification with fuel reburn
SNCR	Selective non-catalytic reduction
SCR	Selective catalytic reduction
O	Other
U	Uncontrolled
OFA	Overfire air
Blank	No information reported for the Stack/Unit ID

Table B2 provides State-level summaries of the 1996 SO_2, NO_x, CO_2, and heat input data for ***coal-fired units***. The resulting national totals for coal-fired units is presented at the end of the table.

Table B3 provides State-level summaries of the 1996 SO_2, NO_x, CO_2, and heat input data for ***non-coal-fired units***. The resulting national totals for non-coal-fired units is presented at the end of the table.